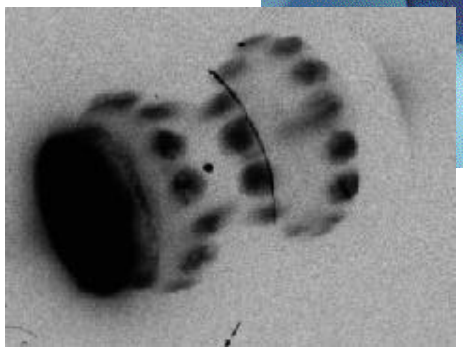
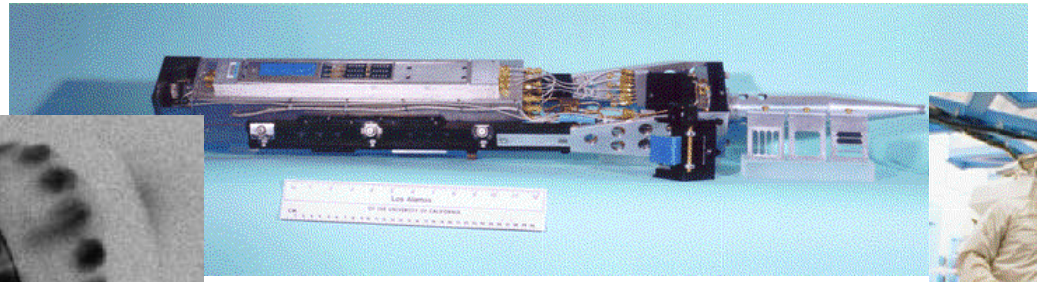
Diagnostic Development for Inertial Confinement Fusion Research at Los Alamos National Laboratory





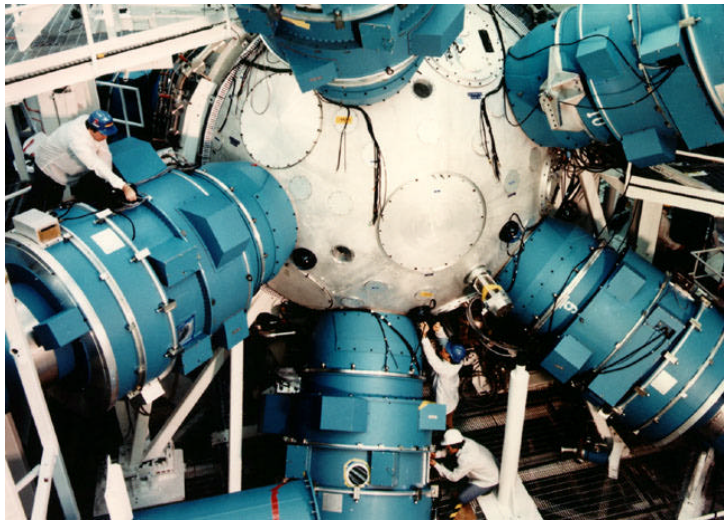
Thomas J. Murphy
P-24 Plasma Physics

Los Alamos
NATIONAL LABORATORY

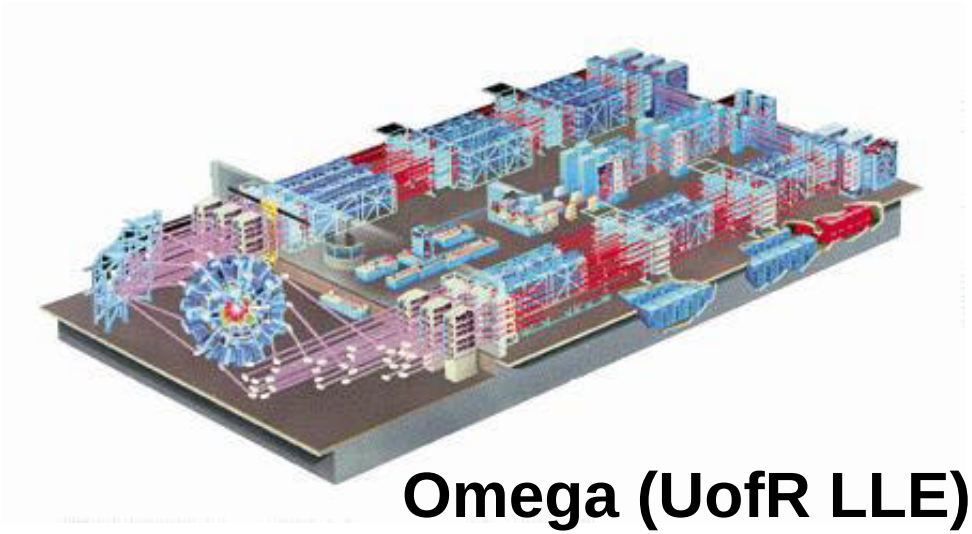
Presented at:
9th National Topical Conference on High-Temperature Plasma Diagnostics
St. Petersburg, Russia

This work was performed under the auspices of the U. S. Department of Energy by Los Alamos National Laboratory under contract No. W-7405-Eng-36.

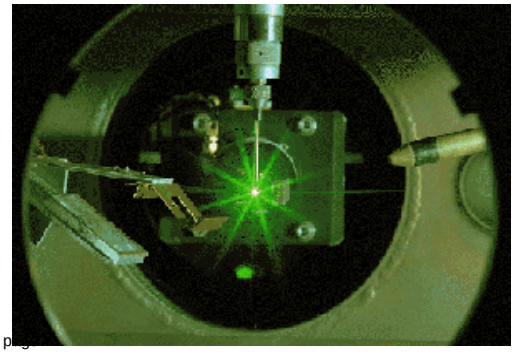
LANL indirect-drive research takes place at Nova, Omega, and Trident



Nova (LLNL)
10 beams
35 kJ



Omega (UofR LLE)
60 beams
40 kJ



Trident (LANL)
2 beams
0.5 kJ

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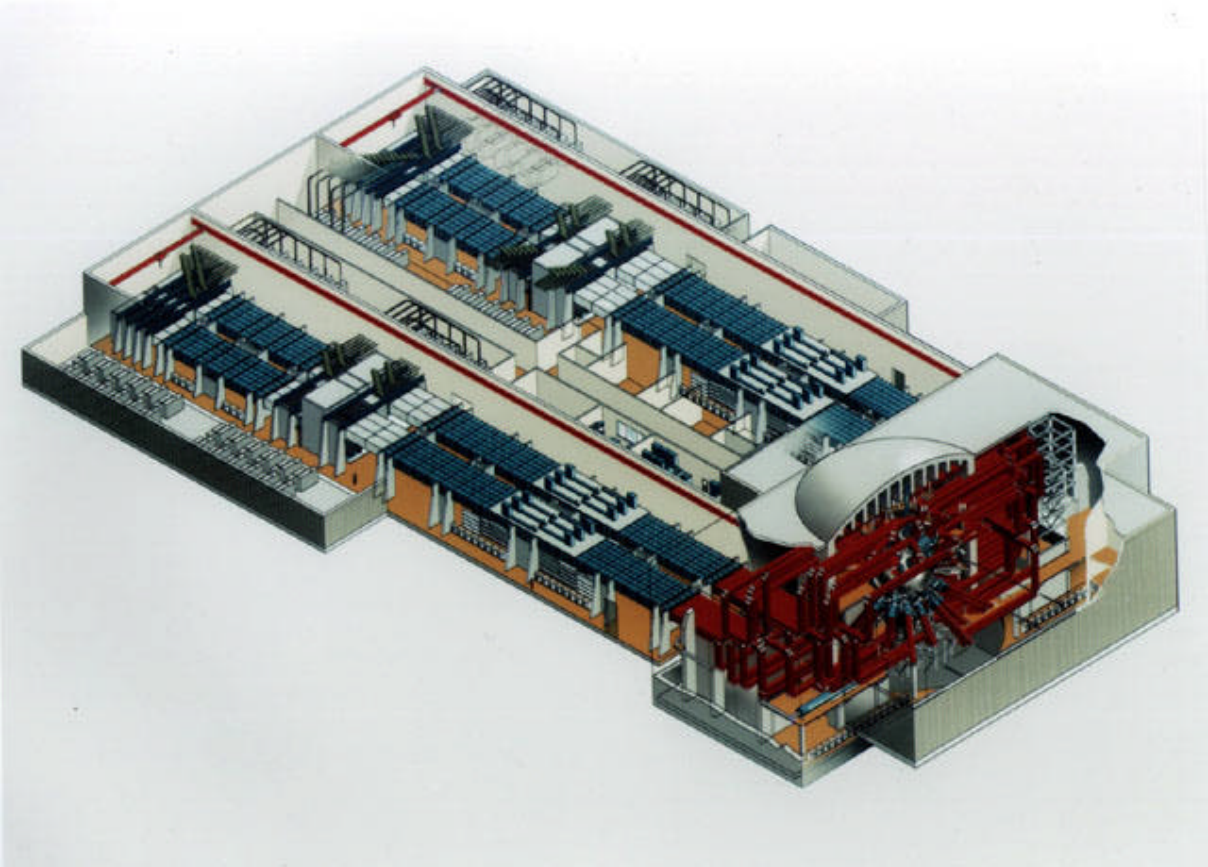
In the next century, the National Ignition Facility will be the focus of the U. S. effort in ICF



To be built at LLNL

192 beams

1.8 MJ

0.35 μm

Begin operation:
July 2002

Full energy:
September 2004

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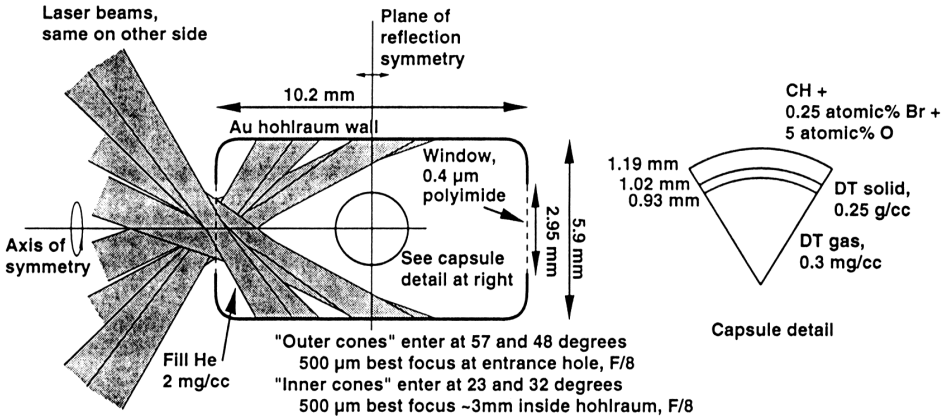
We study laser-plasma interactions because of their implication for indirect-drive ignition on NIF

- Backscatter reduces energy available to drive a hohlraum
- Beam deflection changes drive symmetry
- NIF ignition target designs use gas-filled hohlraums making laser-plasma interaction physics important to ignition



J. D. Kilkenny *et al*, Rev. Sci. Instrum. 66, 288 (1995).

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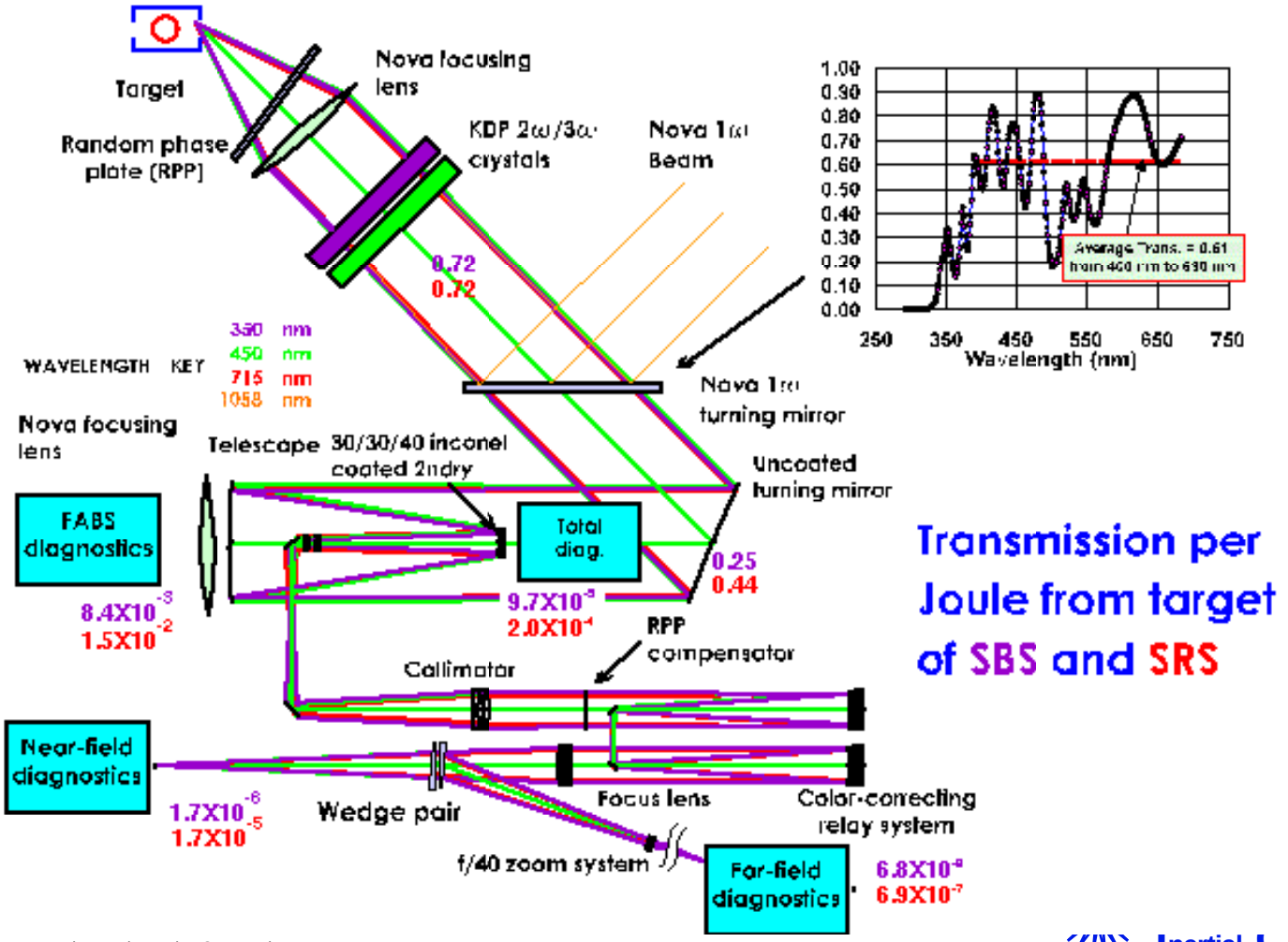
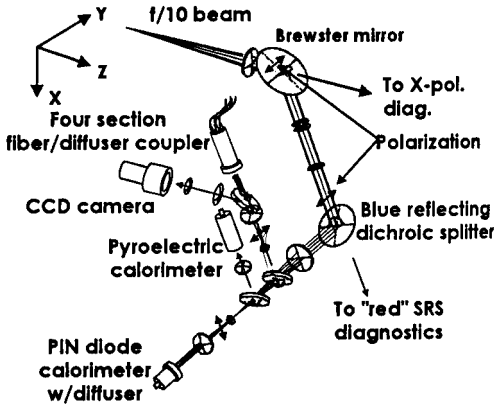
We have developed an instrument that can image light backscattered from the target



Transmission per Joule from target of SBS and SRS

Inertial Confinement Fusion

Data is obtained for both near- and far-field images

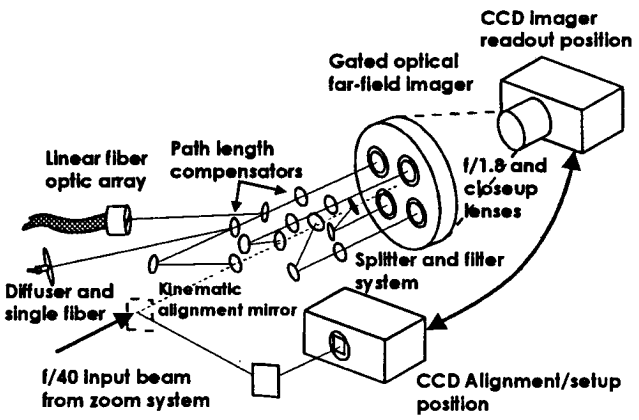


Near-field diagnostics give:

- levels of backscatter
- backscatter spectrum
- polarization of backscatter

Far field diagnostics give:

- gated images of backscatter in
  - SRS (Raman)
  - SBS (Brillouin)



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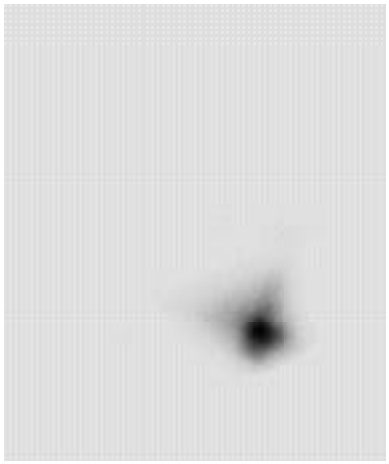
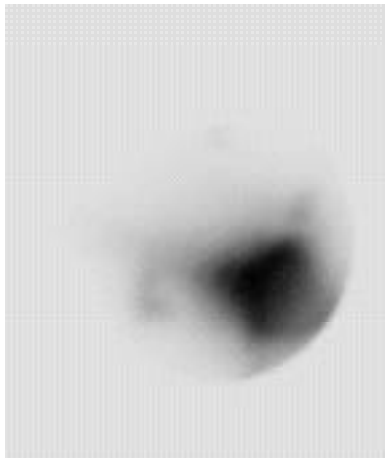
We have obtained results showing different behavior for SRS and SBS



SBS

300 µm at target



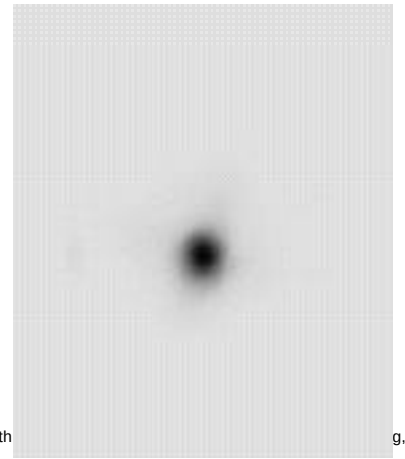
Focused 1000 µm from laser best focus

80% CF_4

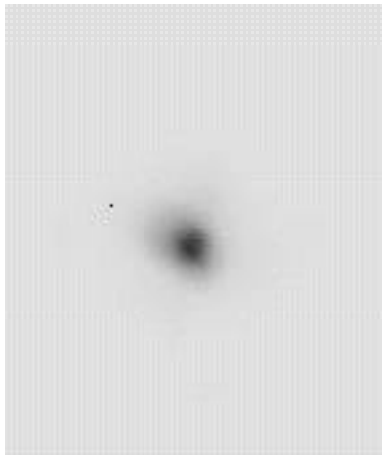
20% C_5H_{12}

t = 700-825 ps

t = 1000-1125 ps



SRS



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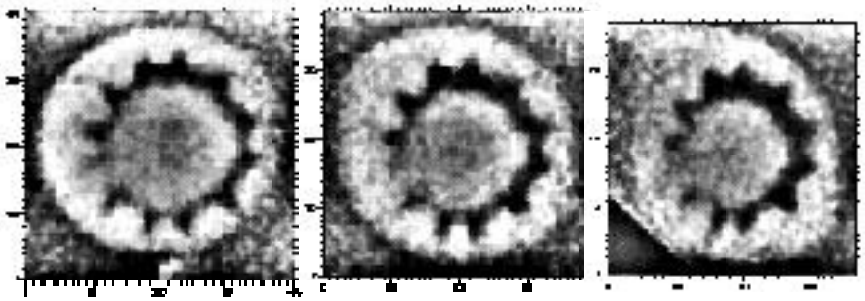
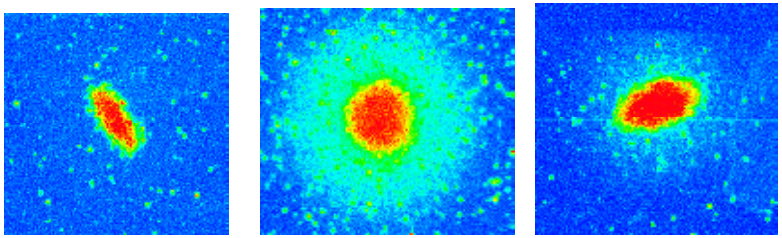
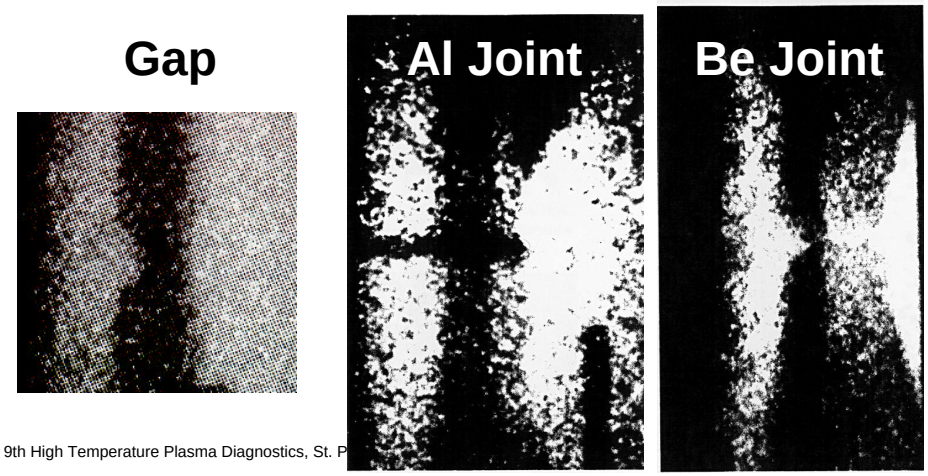
Much of our work is performed using x-ray imaging and would benefit from higher resolution



- Implosion of cylinders with manufactured perturbations



- Implosion symmetry measurements



- Effects of gaps and joints on beryllium ICF capsules

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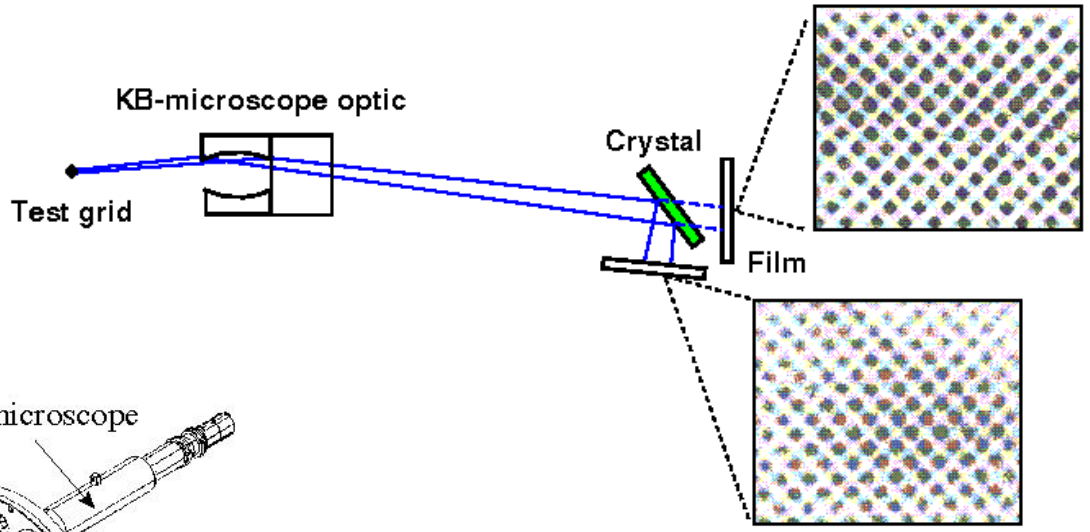
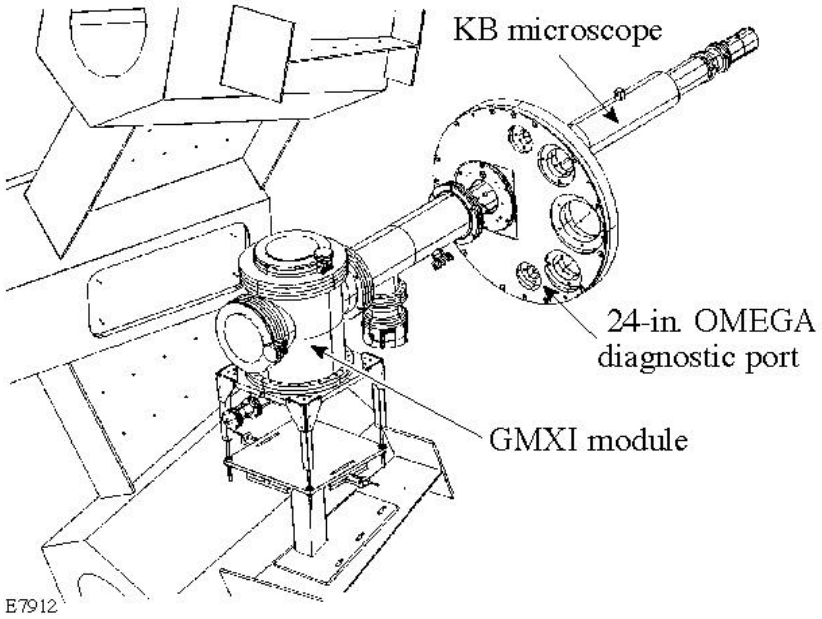
In a collaboration with the University of Rochester Laboratory for Laser Energetics we have developed a Gated Monochromatic X-ray Imager

Utilizes a Kirkpatrick-Baez microscope optic





Resolution of 5 μm is obtained

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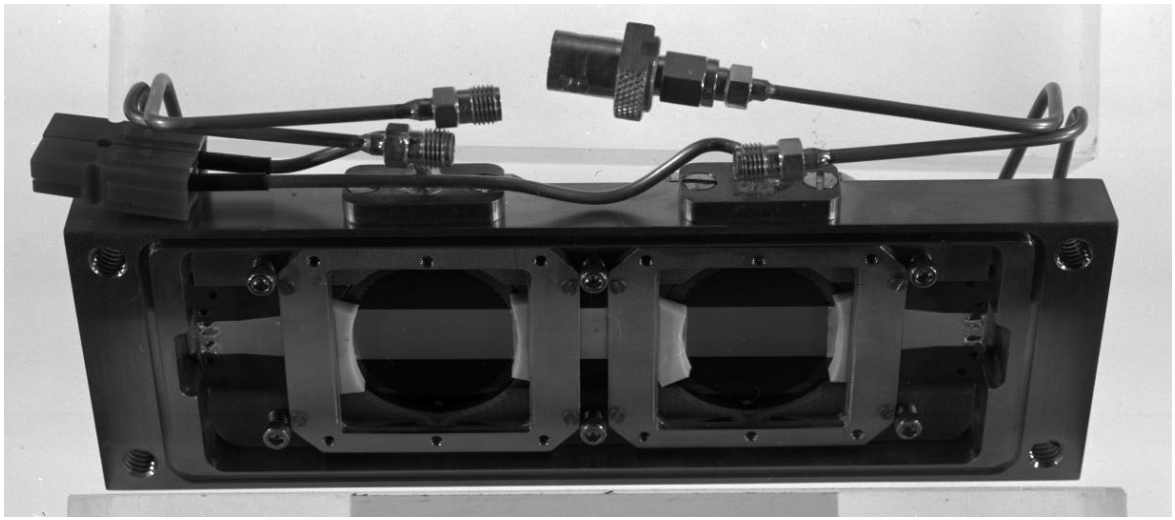
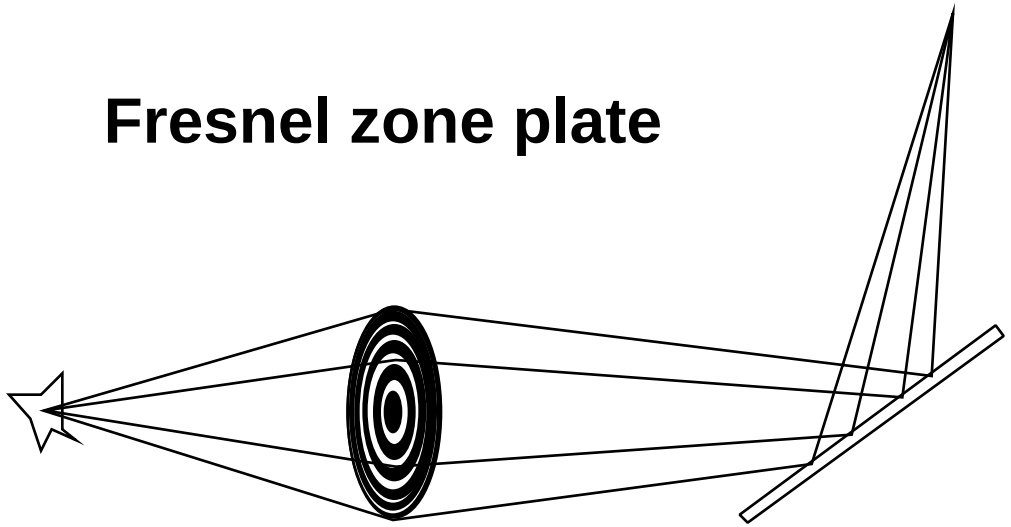
Los Alamos developed a dual microchannel plate gated module for the GMXI

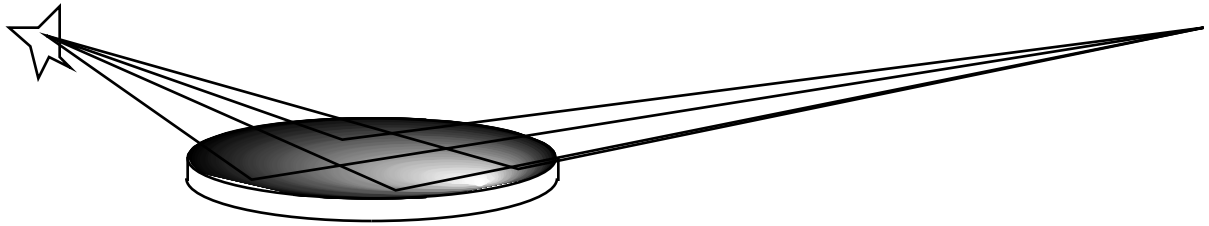


- Each module records two images 350 ps apart
- Two modules are used, giving four gated images

We will also investigate other methods for high-resolution x-ray imaging

Fresnel zone plate





Curved crystal or layered synthetic microstructures

For operation on Nova, Omega, or NIF, an instrument which fits in a diagnostic manipulator is desired.

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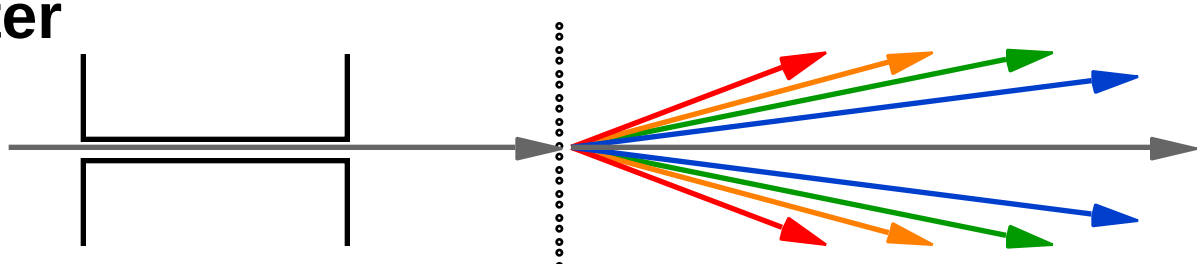
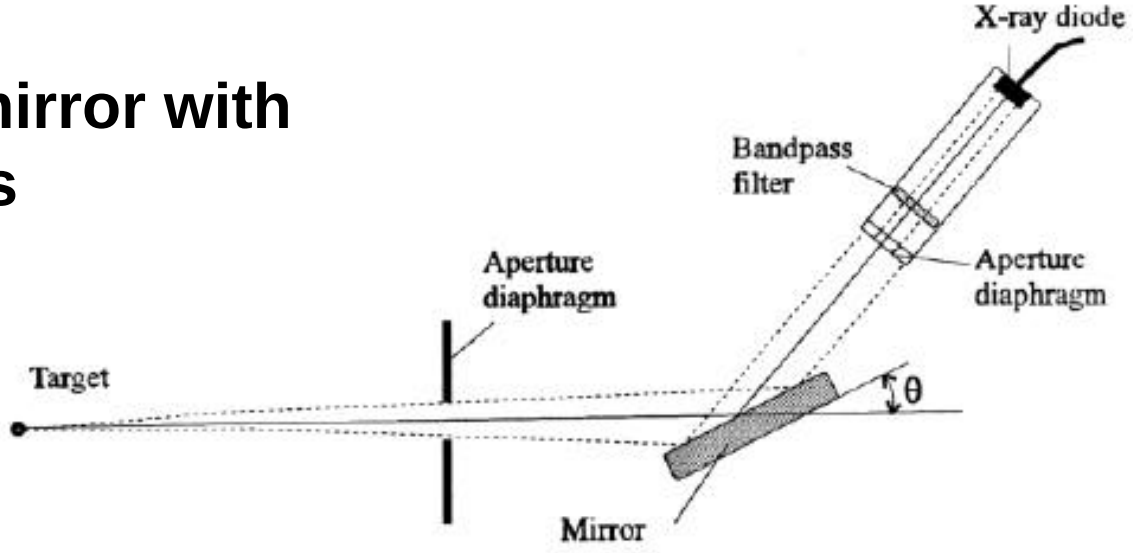
We are investigating new methods for measuring radiation temperature from hohlraums

Transmission grating spectrometer



Multilayer mirror with x-ray diodes



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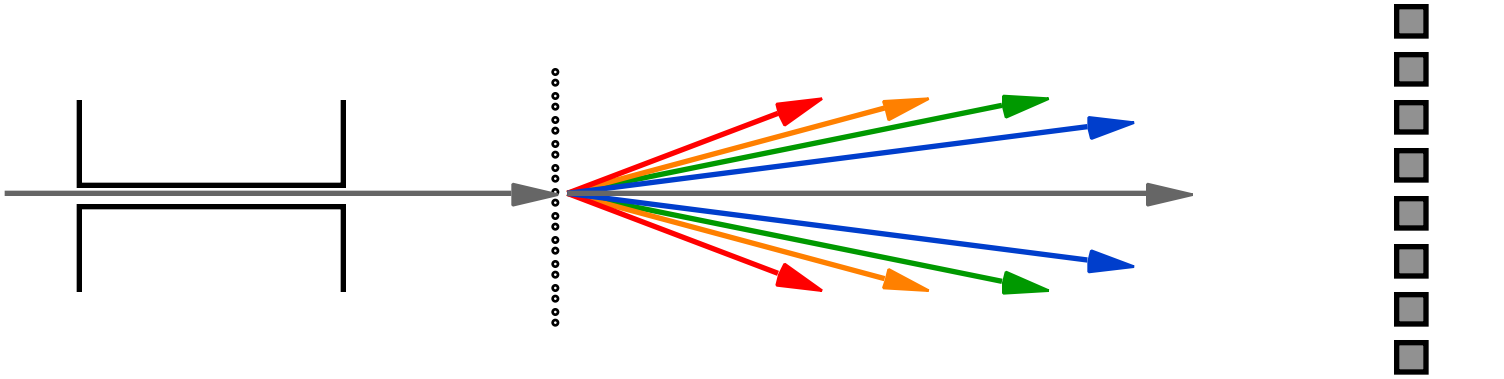
On Nova and Omega, grazing incidence mirrors are used with x-ray diodes and filters to make soft-x-ray power measurements

- Data requires deconvolution due to complicated response functions
- Deconvolutions may not be unique
- Overlapping response functions allow full coverage of spectral region of interest
- Requires complicated calibration of many components

Transmission grating spectrometers would allow direct measure of the x-ray spectrum



Collimator

Transmission grating

Detector array

Typical transmission grating parameters:

Bar width	0.32 μm
Gap width	0.18 μm
Bar thickness	0.098 μm

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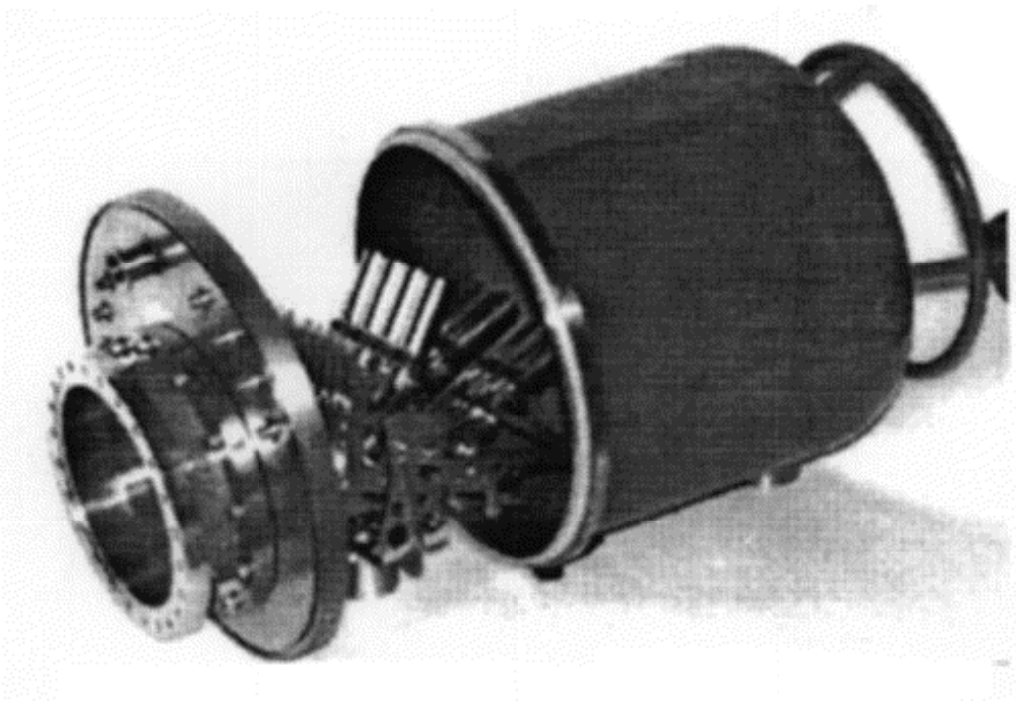
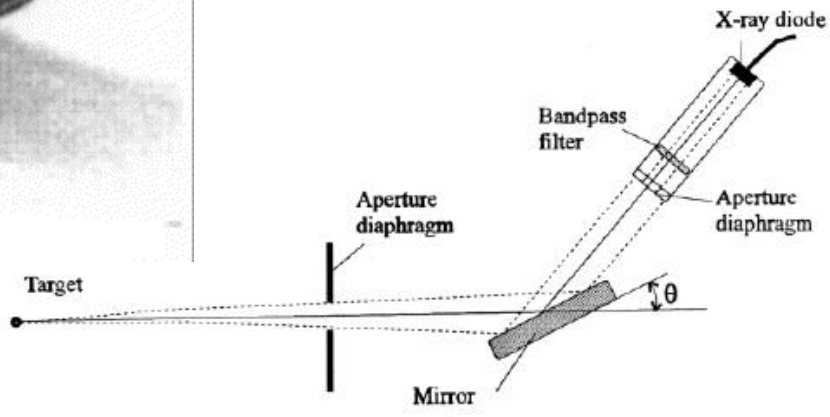
We are also collaborating with VNIIEF to investigate the use of multilayer mirror instruments



LANL:
Dr. J. A. Cobble

VNIIEF:
Dr. A. V. Bessarab
Dr. A. V. Kunin
Dr. V. A. Tokarev



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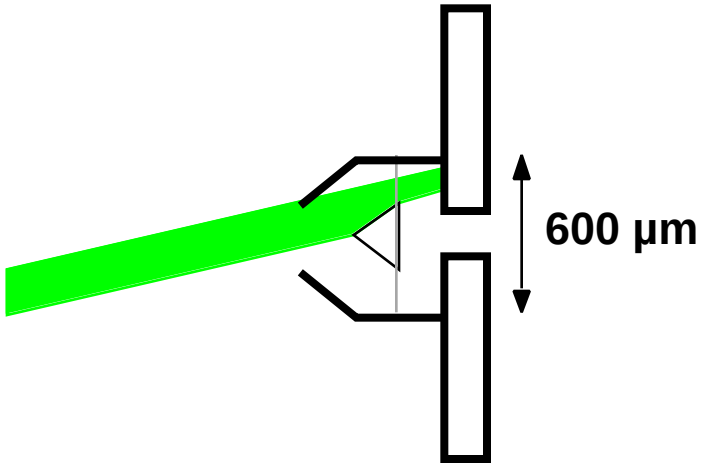
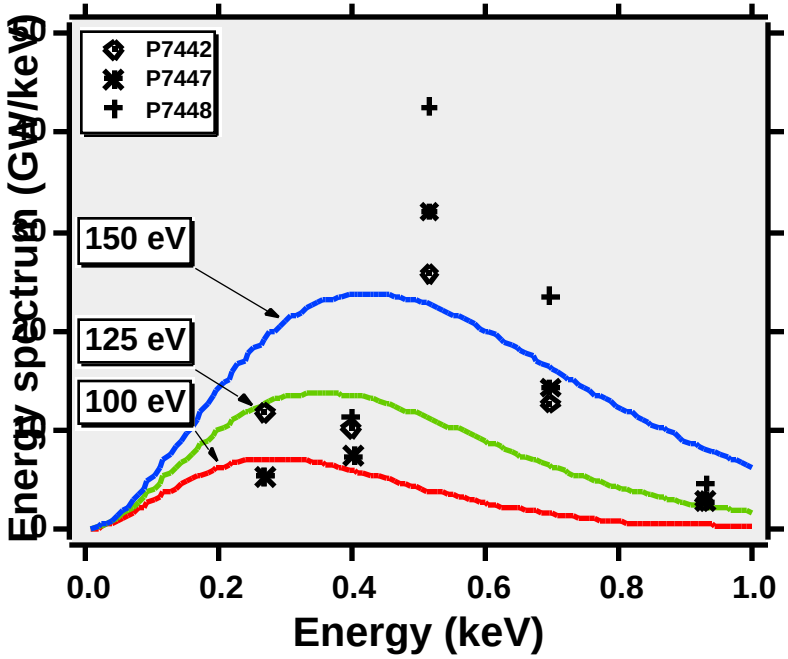
The VNIIEF spectrometer has been used on Trident and we plan to use it on Nova or Omega as well

“Labyrinth” hohlraum





Details of this experiment will be given by Dr. Cobble in his talk

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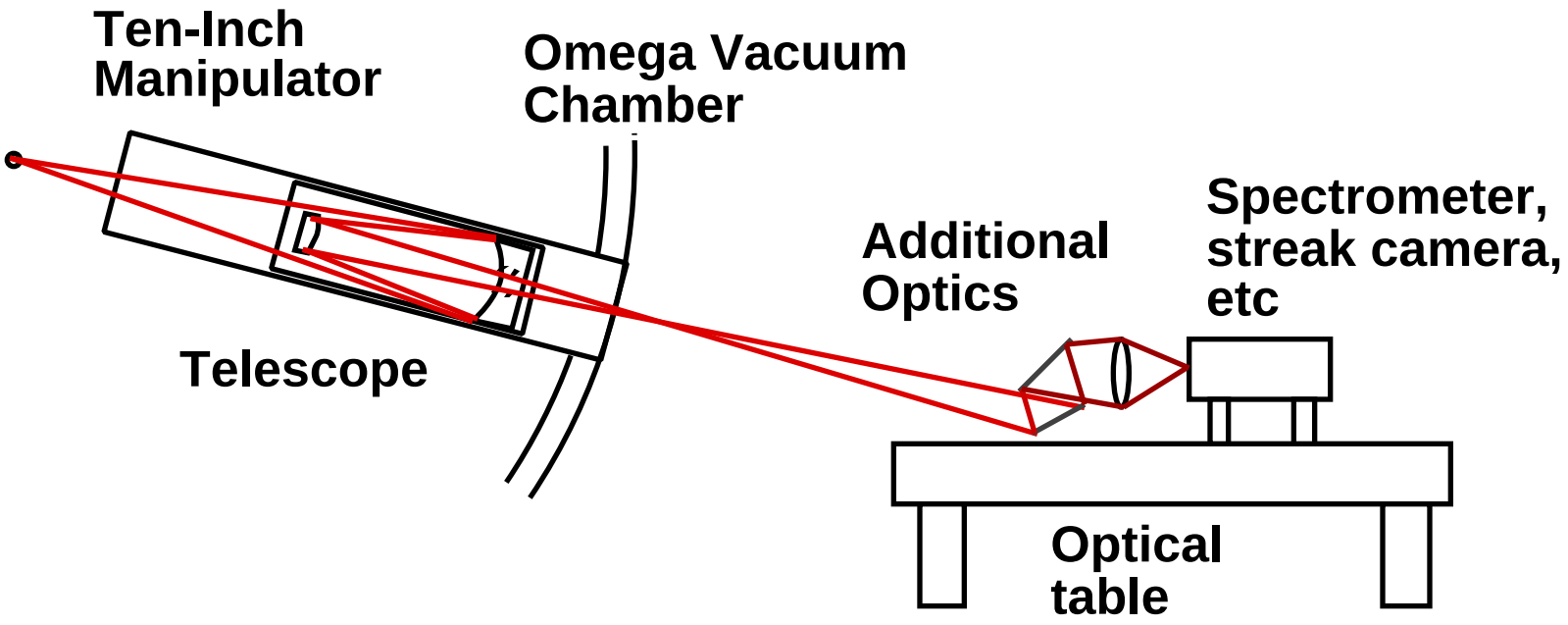
A multi-purpose optical telescope is being designed



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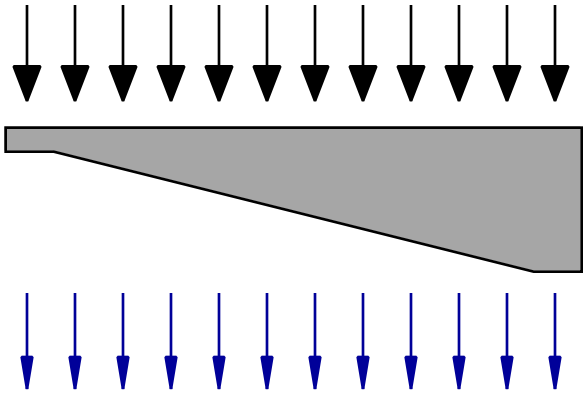
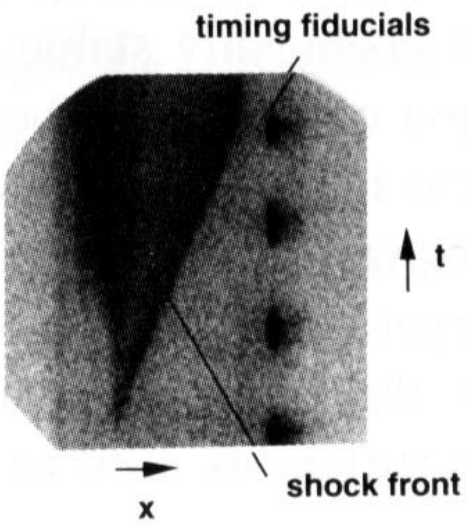
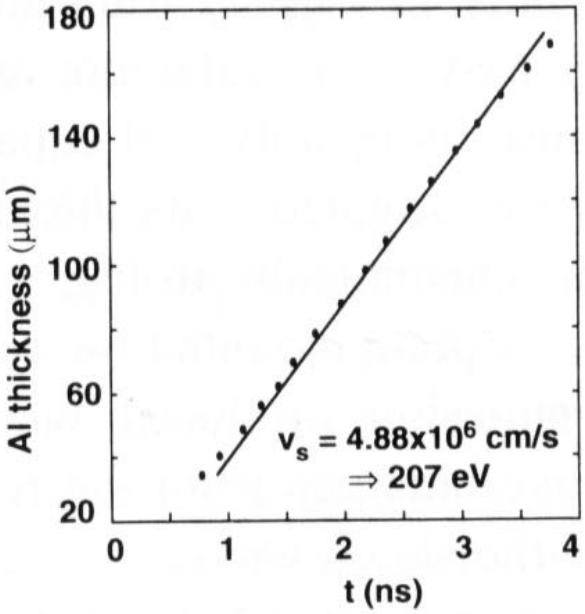
The main purpose of the telescope will be to measure radiation drive in Omega hohlraums

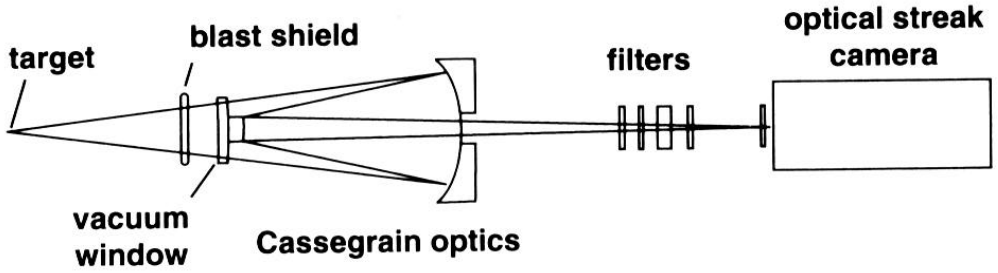
X-ray drive from hohlraum



Optical emission from shock wave







[Kauffman et al. Phys. Rev. Lett. 73, 2320 (1994).]

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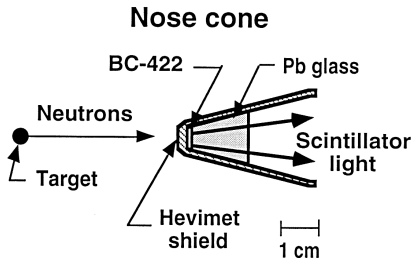
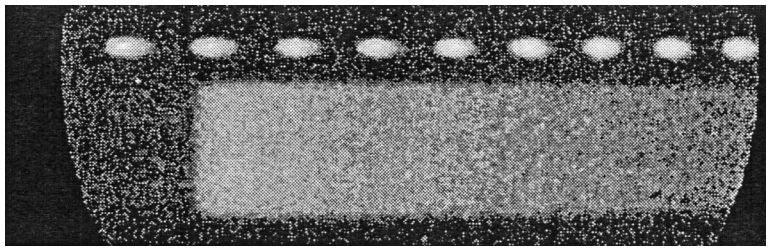
The telescope will also be used for a number of other purposes

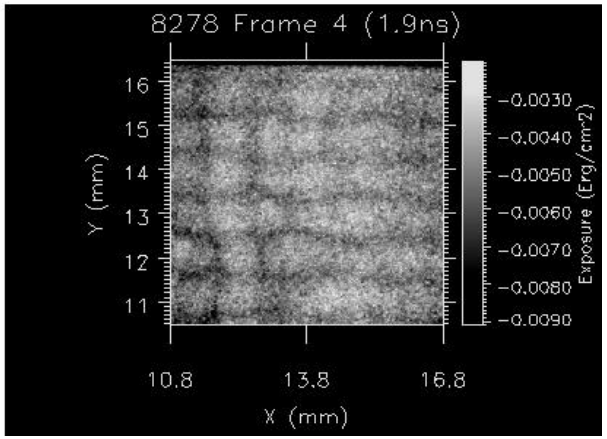
Burn history measurements



fidu

signal





Direct-drive laser imprint studies

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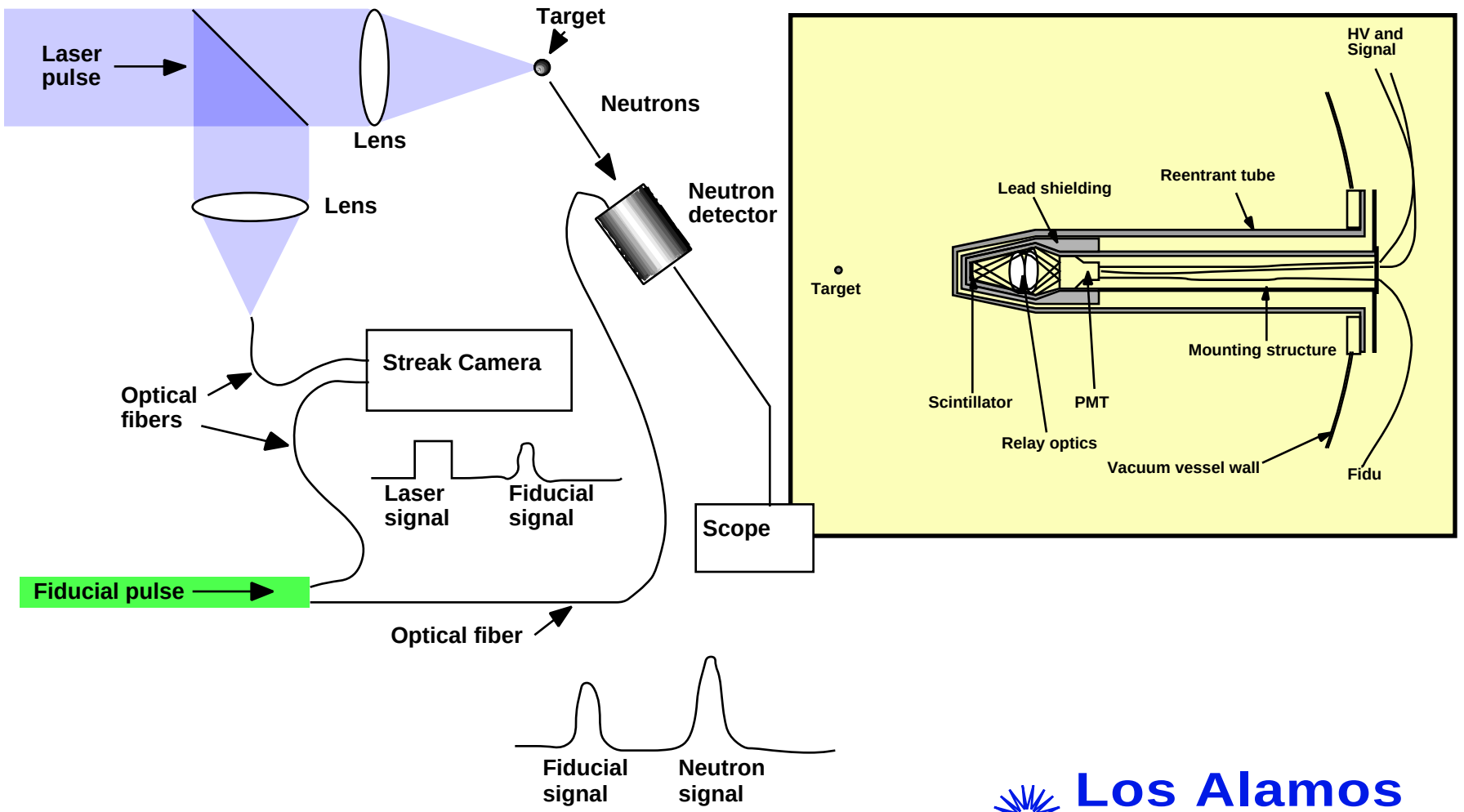
We will be implementing a “bang time” detector on Omega later this year



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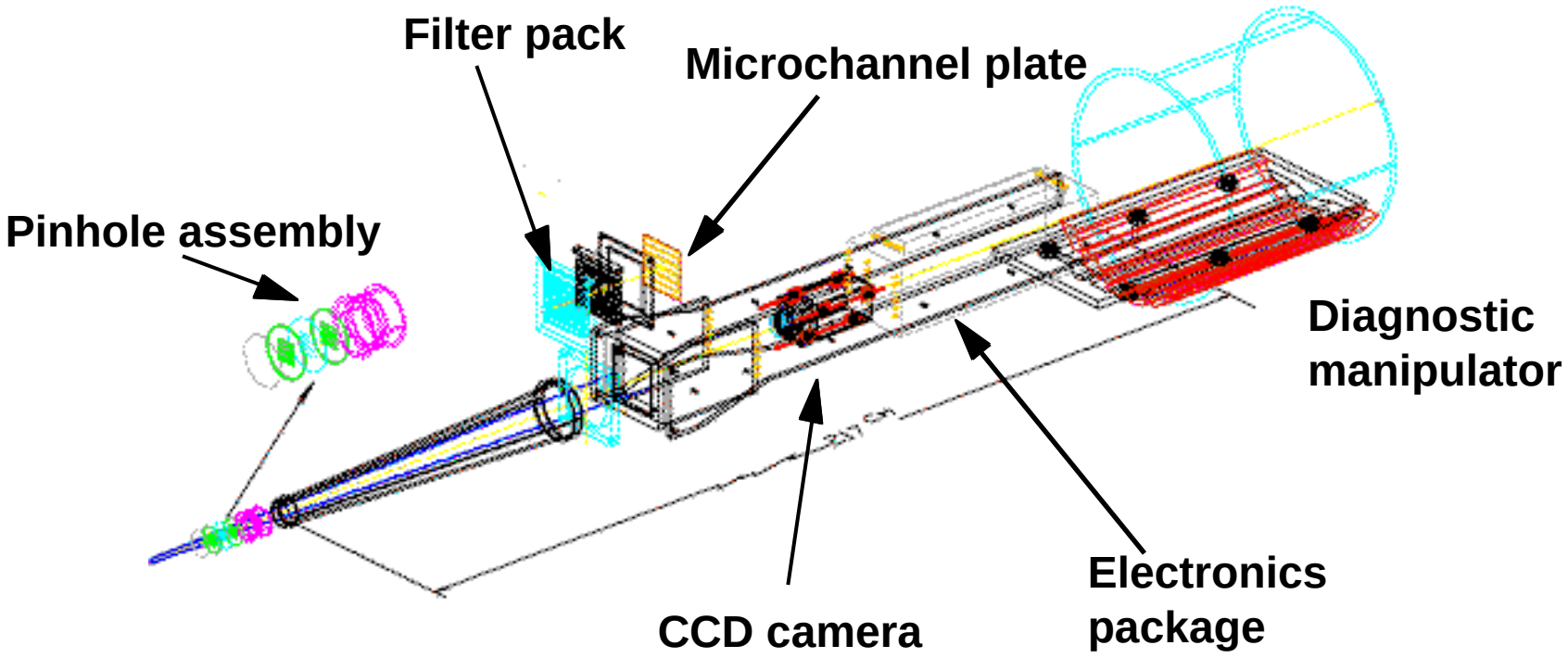
We are designing the gated x-ray imager for NIF



- 30 images in 4.4 ns
- Gate time 80 ps - 1 ns
- CCD or Film readout

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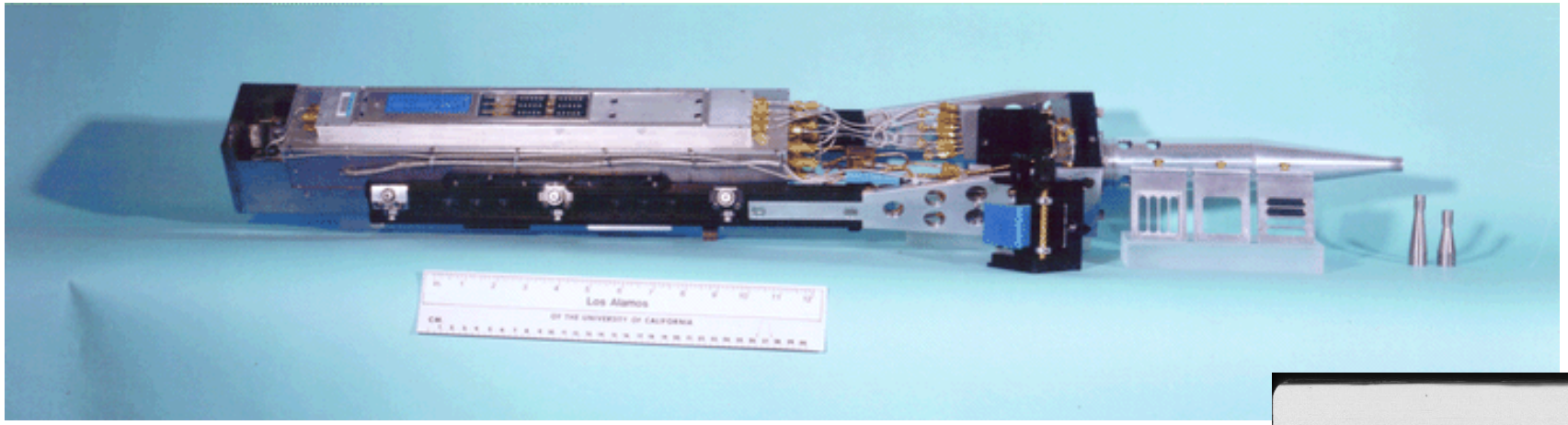
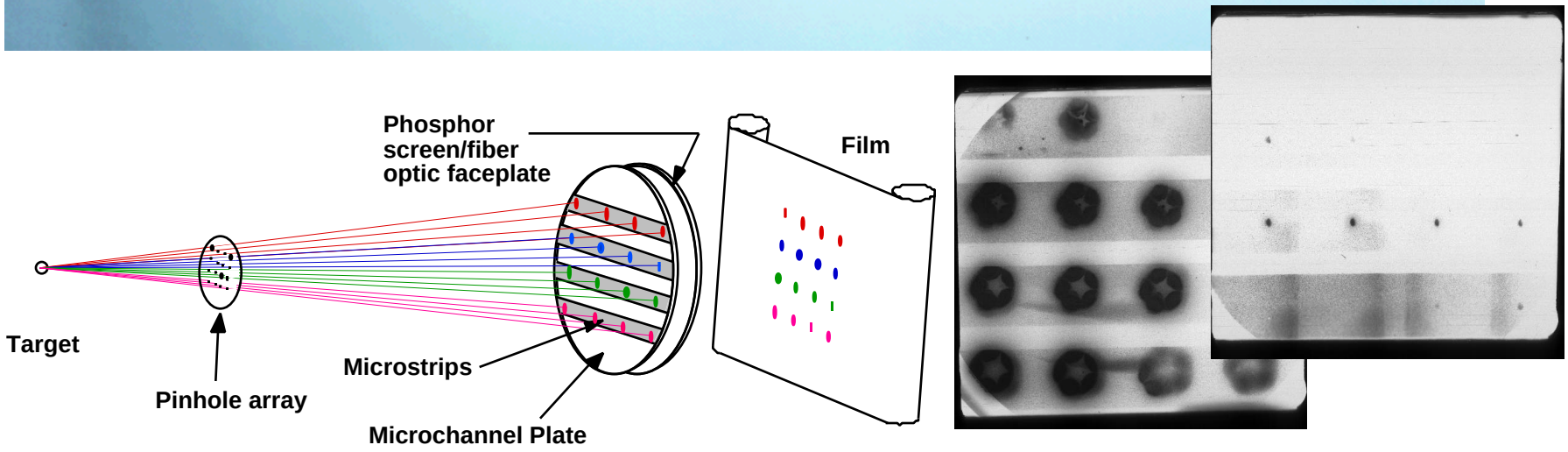
This design is based on gated x-ray imagers built for and used on Nova, Trident, and Omega





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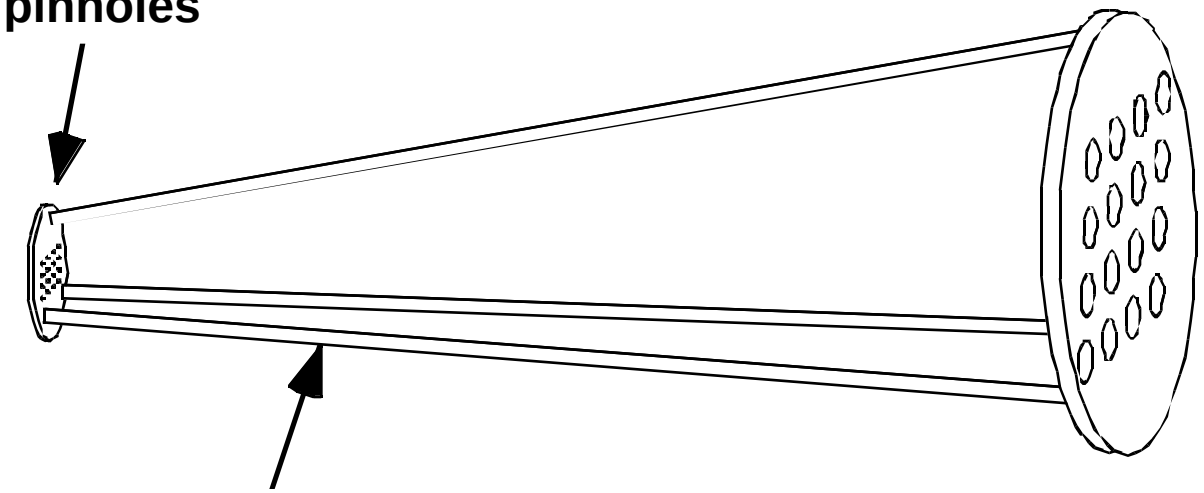
Debris mitigation and detector survivability require modifications to the design of the front end



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LANL is designing diagnostics for Inertial Confinement Fusion experiments designed to help achieve ignition early in the next century

- Full aperture backscatter station
- Optical telescope
- Advanced x-ray spectrometers
- High resolution x-ray imaging
- Bang time detector for Omega
- Time resolved x-ray imager for NIF

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